GLOBE Instrument Specifications

Atmosphere/Climate

Cloud Cover/Type - All Skill Levels

Instrument Specifications: Cloud Chart

The GLOBE cloud chart shall display at least one visual example of each of the 10 basic cloud types — cirrus, cirrostratus, cirrocumulus, altostratus, altocumulus, cumulus, nimbostratus, stratus, cumulonimbus, stratocumulus. Sky cover will be visually estimated. The GLOBE Program will provide a cloud chart to each trained U.S. teacher and to each GLOBE Program Country Coordinator.

Precipitation, Liquid - All Skill Levels

Instrument Specifications: Rain gauge

Precipitation will be measured with a clear view plastic rain gauge with a collector that is at least 102 mm in diameter. The rain gauge must be at least 280 mm in height with a scale indicating rain collected of 0.2 mm or less on an inner clear cylinder. It must have the capacity to measure rainfall of 280 mm without overflowing. The shape of the outer part must also be cylindrical, and overflow from the inner cylinder shall be directed to the outer part of the rain gauge. The outer cylinder must be capable of being used in the inverted position to gather a snow sample for measurement of the water content of snow. The rain gauge must be provided with the necessary hardware for installation on a pole. Instructions for siting are provided in the GLOBE Program Teacher's Guide.

Precipitation, Solid - All Skill Levels

Instrument Specifications: Snow Board

The depth of daily snowfall will be measured with a plywood board which is approximately 40 cm X 40 cm X at least 1 cm thick.

Instrument Specifications: Rain Gauge

The rain gauge described in Precipitation, Liquid will be used for this measurement.

Instrument Specifications: Snow Depth Pole

For snow depths less than 1 meter, a meter stick is recommended. When the snow is deeper than one meter, a snow depth pole is used. This can be made from a 2 meter pole by placing two meter sticks end to end on this pole.

Precipitation pH - All Skill Levels

The same instruments described in Hydrology: Water pH will be used for this measurement.

Air Temperature - All Skill Levels

Instrument Specifications: Maximum/Minimum Thermometer

Air temperature shall be measured with a maximum/minimum thermometer. The maximum/minimum thermometer shall be readable only in degrees Celsius, with maximum and minimum scales marked in increments of 1.0° C, and the scales must be capable of supporting temperature estimations to the nearest 0.5° C. The thermometer must be in a sturdy protective case, and be provided with the necessary hardware for installation. It must be factory calibrated to an accuracy of +1.0° C. Both scales must be adjustable for calibration. Each scale must be clearly marked to indicate Celsius, and have indicators such as "+" and "-" on each scale to indicate direction of increasing and decreasing temperature. In addition, each scale must be clearly marked to identify which scale is maximum and which is minimum. Siting and installation instructions are provided in the GLOBE Program Teacher's Guide.

Instrument Specifications: Calibration Thermometer

The maximum/minimum thermometer will be calibrated with a second thermometer which is an organic liquid-filled thermometer with a temperature range of -5° C to 50° C. The thermometer must be factory calibrated and tested with standards traceable to N.I.S.T (The National Institute of Standards and Technology - United States) to an accuracy of +0.5° C, with 0.5° C scale divisions. It must be supplied with a metal jacket with holes at the bulb end to allow for circulation and a hole at the top by which to hang the thermometer in the instrument shelter for calibration of the maximum/minimum thermometer.

Instrument Specifications: Instrument Shelter

An instrument shelter is required to house the maximum/minimum thermometer and the calibration thermometer to assure scientifically usable air temperature measurements. The instrument shelter must be constructed of a material with a thermal insulation value which equals or exceeds that of seasoned white pine wood (1.8 cm thick). It must be painted white with exterior grade paint. The shelter must be vented, and be large enough to allow air circulation around the thermometer. The inside dimensions must be at least 45 cm high, 22.8 cm wide, and 15.25 cm deep. The shelter must have a hinged door on the front, be louvered on the front and sides, and have holes in the bottom and holes at the uppermost part of the sides to increase ventilation if the louvers do not extend to the top of the sides. The door must contain a lock. The instrument shelter must be mountable onto a wall or post. The top of the shelter must slope downward toward the front. The parts of the shelter must be securely fastened to each other, either using screws or with nails and glue. Joints must be sealed with weather resistant caulking compound.

Hydrology

Water Temperature: - All Skill Levels

Instrument Specifications: Organic liquid-filled thermometer

The calibration thermometer described in Air Temperature will be used for this measurement.

Transparency - All Skill Levels

Instrument Specifications: Secchi Disk Apparatus (for deep water sites only)

5 m length of rope and a disk with a diameter of 20 cm. The disk shall be colored with paint or other appropriate means such that alternate quadrants of each side are black and white. The disk must be made so that it will not be disfigured or damaged by repeated immersion in water, including sea water. It must be weighted such that it remains horizontal while it is lowered by the rope in the water.

Instrument Specifications: Turbidity Tube (for surface water)

Clear plastic tube, approximately 1.2 m long and 4.5 cm diameter with a white cap that fits securely on the end of the tube. The end cap must display a pattern consisting of alternating black and white quadrants on the side that is viewed by looking down the tube.

Water pH - All Skill Levels

Note: The instrument requirements for this measurement vary according to skill level. Please select the appropriate instrument for your students.

Skill Level - Beginning

Instrument Specifications: pH Paper

The pH of standing water at this skill level will be measured with pH paper which can be purchased in strips or rolls. The pH paper must have +1.0 pH unit accuracy, with a range pH 1 to pH 14.

Skill Level - Intermediate

Instrument Specifications: pH Pen

The pH of standing water at this skill level will be measured with a pH pen. The GLOBE instrument must have an accuracy of +0.2 pH units with a range of pH 1 to pH 14. The operating temperature range must be 0 C to 50 C. The pH pen must be capable of being calibrated using a known pH buffer solution.

Skill Level - Advanced

Instrument Specifications: pH Meter

The pH of standing water at this skill level will be measured with a pH meter. The pH meter must have an accuracy of +0.1 pH unit, and a range of pH 1 to pH 14, at temperatures from 0 C to 50 C. The device shall automatically compensate the reading when it is placed in solutions of differing temperature. The pH meter must be capable of being calibrated automatically using known pH buffer solutions.

Skill Level - Intermediate, Advanced

Instrument Specifications: Buffers

pH buffer solutions are required to calibrate the pH pen and meter. The buffer solutions should have a value of pH 4.0, pH 7.0 and pH 10.0; only the pH 7.0 buffer is required for the pH pen at the intermediate skill level.

Dissolved Oxygen - Intermediate, Advanced Skill Levels

Instrument Specifications: Dissolved Oxygen Kit

A dissolved oxygen test kit can be purchased. Teachers or manufacturers who wish to use or prepare another version should ensure that it also meets the following requirements:

- Enables measurement of dissolved oxygen with an accuracy of at least +/- 1 mg/L
- Contains all the chemicals and special containers to perform this measurement based on the Winkler titration method. This method is described in Standard Methods for the Examination of Water and Wastewater, 19th edition, 1995, a publication of the American Public Health Association, Washington, DC.
- Contains clear instructions for using the kit to make this measurement using a procedure based on the Winkler titration method.

Alkalinity - Intermediate, Advanced Skill Levels

Instrument Specifications: Water Alkalinity Kit

A water alkalinity kit can be purchased. Teachers or manufacturers who wish to use or prepare another version should ensure that it also meets the following requirements:

- Enables measurement of total alkalinity with an accuracy of at least 6.8 mg/L as CaCO3 (low range, under 136 mg/L), and 17 mg/L as CaCO3 (high range, above 136 mg/L).
- Contains all chemicals and containers needed to perform the alkalinity titration, including: 1) Bromocresol green-methyl red indicator and scoop for adding the required amount to the

sample, 2) sulfuric acid for titration, and method of delivering acid to sample to achieve the required accuracy, 3) measuring containers and bottles for titration. This method is described in Standard Methods for the Examination of Water and Wastewater, 19th edition, 1995, a publication of the American Public Health Association, Washington, D.C.

- Contains clear instructions for using the kit to make this measurement, based on acid titration to a Bromocresol green-methyl red end point.
- Plastic gloves and safety goggles

Instrument Specifications: Safety Equipment

Plastic gloves and safety goggles must be used in making this measurement.

Electrical Conductivity (for fresh water sites) - All Skill Levels

Instrument Specifications: Electrode-type total dissolved solids tester (conductivity meter)

This device shall measure electrical conductivity of liquid solutions using two metal electrodes separated by a fixed distance. The device shall be designed to be hand-held, and battery powered, with no electrical power cord attached. The device shall employ a method to automatically compensate the indicated conductivity value relative to changes in the temperature of the solution. The measurement range shall be at least from 0-1990 microSiemens/cm, with a resolution of 10 microSiemens/cm, an accuracy of +/- 2% full scale, and an operating temperature of 0-50 C. The device shall be capable of calibration using a standard solution.

Instrument Specifications: Calibration Standard

A solution of KCl and water or NaCl and water that has a conductivity of about 450 microSiemens (225.6 mg/L KCl or 215.5 mg/L NaCl).

Salinity (for brackish and salt water sites) -All Skill Levels

Instrument Specifications: Hydrometer Method

The same instrument described in Soil Particle Size will be used for this measurement.

A 500 mL clear plastic cylinder and an organic liquid-filled thermometer for use with the hydrometer are required. The 500 mL cylinder for Soil Particle Size may be used. The calibration thermometer for Air Temperature may be used.

Instrument Specifications: Salinity Titration Method - Optional, Intermediate, Advanced Skill Levels

A salinity kit can be purchased. Teachers or manufacturers who wish to use or prepare another version should ensure that it also meets the following requirements:

- Range: 0 - 20 parts per thousand (ppt)*
- Smallest increment: 0.4 ppt
- Method/chemistry: chloride titration
- Approximate number of tests: 50
- Contains clear instructions for using this kit to make this measurement, based on the chloride titration method.

*Titrator must be refillable for use in higher salinity waters.

Nitrate - Intermediate, Advanced Skill Levels

Instrument Specifications: Water Nitrate Kit

A nitrate kit can be purchased. Teachers or manufacturers who wish to use or prepare another version should ensure that it also meets the following requirements:

- Range: 0 - 10 ppm NO_3-N
- Smallest increment: 0.05 ppm NO_3-N for the range 0 -1 ppm NO_3-N; 0.5 ppm NO_3-N for the range 1 - 10 ppm NO_3-N
- Method/chemistry: cadmium reduction
- Approximate number of tests: 50
- Contains clear instructions for using this kit to make this measurement, based on the cadmium reduction method.

Soil Characterization

Soil Slope - All Skill Levels

Instrument Specifications: Clinometer

The clinometer described in Land Cover: Tree Height will be used for this measurement.

Soil Profile - All Skill Levels

Instrument Specifications: Camera

It is assumed that a camera with color film is available locally.

Instrument Specifications: Meter Stick

A durable ruler with gradations every cm and mm.

Soil Structure - All Skill Levels

Instrument Specifications: None

Color - All Skill Levels

Instrument Specifications: Color Chart

A soil color chart designed especially for the GLOBE Program can be purchased. It contains at least 200 colors and uses the Munsell System of Color Notation. This flip chart is weather-resistant and has large color chips which are edge-mounted for ease of reading. The color range includes all hues found in the full set of International soil colors, yet provides a selected set of values and chroma to aid color identification for students. Manufacturers who wish to prepare another version should contact the GLOBE Program for the complete list of colors.

Soil Consistence - All Skill Levels

Instrument Specifications: None

Soil Texture- All Skill Levels

Instrument Specifications: None

Free Carbonates - All Skill Levels

Instrument Specifications: Vinegar

Distilled white vinegar. Household vinegar may be used.

Instrument Specifications: Acid Squirt Bottle

A bottle capable of safely holding at least 200 mL of acid is required.

Sample Preparation for Bulk Density, Particle Size, Soil pH, and Fertility Protocols - All Skill Levels

Instrument Specifications: Sieve

Number 10 sieve with 2 mm mesh attached to a frame.

Soil Bulk Density - All Skill Levels

Instrument Specifications: Graduated Cylinder -100 mL

Glass graduated cylinder with a capacity of 100 mL marked in 1 mL or smaller divisions, with graduations covering at least the range from 10 mL to 100 mL.

Instrument Specifications: Balance and Augers

The same balance and auger used for Gravimetric Soil Moisture will be used for Bulk Density.

Instrument Specifications: Soil Sample Cans and Other Soil Containers

Cans and containers should meet the same specifications as given for these items for Gravimetric Soil Moisture

Soil Particle Size - All Skill Levels

Instrument Specifications: Hydrometer

The hydrometer used should meet the following requirements:

- Calibrated to specific temperature for water and sample (e.g. 15.6 C / 15.6 C
- Range (specific gravity / no units): 1.0000 - 1.0700
- Smallest increment (no units): 0.0005

Instrument Specifications: Thermometer

The Calibration Thermometer described in Air Temperature will be used for this measurement.

Instrument Specifications: 500 mL Clear Plastic Graduated Cylinder

One 500 mL capacity plastic graduated cylinder, marked at least at the 500 mL level. Cylinder must be clear plastic, not frosted plastic and not glass. Instrument Specifications: Dispersing Solution Sodiumhexametaphosphate powder or a 10% solution of either sodiumhexametaphosphate or a detergent that does not produce suds.

Soil pH - All Skill Levels

Instrument Specifications: pH measurement devices

The same instruments described in Hydrology: Water pH will be used for this measurement.

Instrument Specifications: Graduated Cylinder -100 mL

The same instrument as described in Bulk Density will be used for this measurement.

Soil Fertility - Intermediate, Advanced Skill Levels

Instrument Specifications: Soil NPK (Macronutrients) Kit

The test kit must:

- Contain unit-dose reagents and containers needed to extract soil nutrients from 50 samples and to perform 50 tests of each: soil nitrogen; soil phosphorus; and soil potassium.

- Employ methods based on the Spurway extraction method, the zinc reduction/chromotropic acid method for nitrogen, the ascorbic acid reduction method for phosphorus, and the sodium tetraphenylboron (turbidimetric) method for potassium.
- Contain clear instructions, including diagrams, for using the kit.
- Contain a water resistant color chart for interpreting the results of colorimetric tests and a turbidity chart for the turbidimetric test.

Soil Moisture and Temperature

Gravimetric Soil Moisture - All Skill Levels

Instrument Specifications: Balance

This balance must have the capacity to weigh 300 grams with an accuracy of +/- 0.1 gram. It can be either mechanical or electronic. It is assumed that a balance is available locally, for example in a high school science laboratory.

Instrument Specifications: Drying Oven (soils)

Drying oven capable of holding a temperature of 95 C - 105 C for at least 10 hours or a temperature of 75 C - 95 C for 24 hours. The oven must be ventilated, and have interior dimension of at least 25 cm x 30 cm x 25 cm. It is assumed that an oven is available locally, for example in a high school science laboratory.

Instrument Specifications: Microwave Drying Oven

Any microwave oven compatible with school use.

Instrument Specifications: Soil Sample Cans

15 round sample tins. A metal container with a diameter 7 cm, and height 5 cm, with a removable cover is appropriate as are small round, cleaned food cans. Cans must be capable of having a small hole punched in their bottoms.

Instrument Specifications: Other Soil Containers

15 containers large enough to have soil samples transferred into them directly from an auger without loss of sample. Glass jars, plastic food containers with lids, or other containers that can be covered and that can hold the soil samples while they are dried in the drying oven selected.

Instrument Specifications: Dutch Auger For Combination Soils

Dutch (or Edelman) auger for combination soils with a head having the minimum dimensions of 7 cm wide and 18 cm long. The unit (head and shaft inclusive) should be at least 120 cm long in order to be suitable to dig a hole up to 1m deep. It should be of one piece welded construction.

Instrument Specifications: Dutch Auger For Sandy Soils

Auger designed for sandy soils with a head having the minimum dimensions of 7 cm wide and 18 cm long. The unit (head and shaft inclusive) should be at least 120 cm long in order to be suitable to dig a hole up to 1m deep. It should be of one piece welded construction.

Instrument Specifications: Bucket Auger

Bucket (or Riverside) auger designed for hard and brittle soils with a head having the minimum dimensions of 7 cm wide and 18 cm long. The unit (head and shaft inclusive) should be at least 120 cm long in order to be suitable to dig a hole up to 1m deep. It should be of one piece welded construction.

Instrument Specifications: Peat Auger

Auger designed for peat soils with a head having the minimum dimensions of 7 cm wide and 18 cm long. The unit (head and shaft inclusive) should be at least 120 cm long in order to be suitable to dig a hole up to 1m deep. It should be of one piece welded construction.

Gypsum Block Soil Moisture - Optional, Advanced Skill Level

Instrument Specifications: Gypsum Blocks

Cast gypsum blocks: approx. 25 mm high x 20 mm diameter; in which concentric stainless steel mesh electrodes are embedded; 1.5-2.0 meter insulated lead wire soldered to electrodes

Instrument Specifications: Soil Moisture Meter

Hand-held AC conductivity meter designed for use with gypsum blocks (described above); push button calibration/compensation and push button digital reading. Conductivity may be normalized to between 0 and 100. The unit must have two terminals which enable attachment and removal of electrical conductor wires on a daily basis. The unit must be battery powered and be capable of being hand-held and used in remote locations.

Instrument Specifications: PVC Piping

The PVC pipe assists in placing the gypsum block sensors in the ground. It should be 90 cm in length and approximately 2 cm in diameter. Additional PVC piping is required to mark the location of the sensors. These should be 23 cm long with a diameter of approximately 5 cm. Four pieces of this material are required.

Infiltration — All Skill Levels

Instrument Specifications: Dual Ring Infiltrometer

Two concentric metal cylinders. The inner one must have a diameter of 10 cm to 25 cm. The outer one must have a diameter at least 10 cm larger than the inner cylinder. Both cylinders should be 10 to 15 cm high and open at both ends. Steel cans may be found which will work for this apparatus.

Soil Temperature- All Skill Levels

Instrument Specifications: Soil thermometer

A 11 cm to 20 cm stainless steel probe, heavy-duty construction dial or digital thermometer with a range of at least -10 to 50 degrees C (Celsius scale required) and an accuracy of 1% full scale (over a range of no more than 200 degrees C) or better is required. The sensor should be in the bottom third of the probe. The sensor should give stable readings after less than 60 seconds in an isothermal bath. Batteries, if required, should be included. The sensor should be adjustable with the calibration procedure and achievable accuracy clearly stated. Dial thermometers must be sealed against fogging and be covered with shatterproof glass or plastic. Scale graduations of 1.0 degrees C and 0.1 degrees C are preferred for dial and digital thermometers, respectively. Glass stem thermometers are NOT acceptable.

Land Cover/Biology

Land Cover - All Skill Levels

Instrument Specifications: Landsat Thematic Mapper (TM) Image, MultiSpec software.

The GLOBE Program will provide a TM image to all US schools. MultiSpec software is available for downloading from the Internet.

Species Identification - All Skill Levels

Instrument Specifications: Dichotomous Keys

Dichotomous keys for tree identification are not available from a central supplier; they need to be acquired locally.

Biometry
Layout of the Biology Site - All Skill Levels

Instrument Specifications: Tape Measure

50 m tape, graduated one side, marked in 2 mm or smaller units.

Tree Circumference - All Skill Levels

Instrument Specifications: Tape Measure

The tape measure described in Layout of the Biology Site will be used for this measurement.

Tree Height - All Skill Levels

Instrument Specifications: Tape measure

The tape measure described in Layout of the Biology Site will be used for this measurement.

Instrument Specifications: Clinometer

The clinometer may be made by students from plans in the GLOBE Teacher's Guide, or may consist of a moveable dial within a metal case and lens viewer. For the moveable dial version, the scale must be graduated from 0-90º in 1º units.

Canopy Cover - All Skill Levels

Instrument Specifications: Densiometer

The densiometer may be made by students according to instructions in the GLOBE Teacher's Guide.

Ground Cover - All Skill Levels

Instrument Specifications: none

Grass Biomass - All Skill Levels

Instrument Specifications: Balance

This balance must have the capacity to weigh 300 grams with an accuracy of +/- 0.1 gram. It can be either mechanical or electronic. It is assumed that a balance is available locally, for example in a high school science laboratory.

Instrument Specifications: Drying Oven (plants)

This oven must be capable of holding samples at 50-70 C for up to two days and must be ventilated to allow moisture to escape. The interior dimensions of the oven must be at least 25 cm x 30 cm x 25 cm. It is assumed that an oven is available locally, for example in a high school science laboratory. The oven should be designed for drying biological samples or food and should not be a conventional cooking oven, which could present a fire hazard in this application.

GPS

Latitude, Longitude and Elevation of GLOBE Study Sites - All Skill Levels

Instrument Specifications: Global Positioning System (GPS) Receiver

The instrument must be capable of:

- Expressing latitude and longitude in whole degrees, minutes and decimal minutes to the nearest 0.01 minutes and
- Displaying time on screen in units of UT hours, minutes, and seconds,
- Using the WGS-84 map datum, and
- Displaying elevation in meters.

US Schools may request to borrow a unit from UNAVCO at

UNAVCO/UCAR
PO Box 3000, UN 393
Boulder, CO 80307-3000
email: globe@unavco.ucar.edu
Tel. (303) 497-8000
Fax. (303) 497-7857

Non-US Schools should contact their GLOBE Country Coordinator for information regarding GPS receivers.